UNITED STATES UTILITY PATENT APPLICATION

FOR

ENVIRONMENTALLY SEALED CAMERAS FOR MOUNTING EXTERNALLY ON AIRCRAFT AND SYSTEMS FOR USING THE SAME

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ENVIRONMENTALLY SEALED CAMERAS FOR MOUNTING EXTERNALLY ON AIRCRAFT AND SYSTEMS FOR USING THE SAME

FIELD OF THE INVENTION

The present invention relates to video cameras and, more particularly, to video cameras that are sealed to the environment. The cameras of the present invention are particularly beneficial when mounted to the surface of an aircraft where the cameras are subject to a harsh environment. The present invention also relates to methods for manufacturing such cameras and systems for their use.

BACKGROUND OF THE INVENTION

Aircraft-mounted camera systems have several uses. For example, they may be used to provide in-flight entertainment to cabin passengers. Cabin passengers may want to see the same view as their pilot, but are prohibited because cabin windows are small, views are often obstructed by aircraft structures, and access to cabin windows is often restricted by seating configurations. Cabin passengers may realize a more enjoyable flight by watching a display screen that projects an unobstructed, wide-angle forward view of the flight path. Other uses of aircraft-mounted camera systems include safety, security, and surveillance.

Mounting a camera on the outside surface of an aircraft presents several environmental challenges. One of these challenges is temperature extremes. Environmental temperature generally drops as altitude increases. At high altitudes, temperatures may become extremely cold. Camera mounting systems must be designed to prevent fogging and crystallization of vapor on the camera lens or window as a result of temperature change.

Another challenge is vibration. Vibration may be caused by aircraft propulsion systems, turbulence, or the friction and drag forces exerted by high-speed travel. Camera mounting systems must be designed to prevent the camera from being exposed to excessive vibrations that could impair image quality. The mounting system must also be aerodynamic, and seamlessly integrate with the aircraft body in order to maintain aircraft performance and minimize drag.

Camera mounting apparatus found in the prior art tend to be complex and involve numerous moving parts. As a result, they contain expensive components and require complex and, therefore, expensive manufacturing methods.

Accordingly, there is a need for cameras that are able to withstand extreme environmental conditions and for simple, low-cost, aerodynamic mounting apparatus that resists vibration and provides a low-cost heating mechanism to prevent environmental impairment of the camera view at extreme temperatures.

SUMMARY OF THE INVENTION

In a preferred embodiment, the invention provides a simple, low-cost, aerodynamic camera system. A mounting apparatus that cushions a camera with a surrounding vibration-dampening layer of epoxy. The invention incorporates an efficient, low-cost heater that heats the camera window directly rather than heating the entire apparatus. The aircraft-mounted camera system of the invention is easy to manufacture, easy to install, is mechanically simple, and can be manufactured without the need for elaborate and expensive manufacturing equipment.

A camera system according to the preferred embodiment of the invention includes a camera and a housing. The housing conforms to the topography of the aircraft and includes a receptacle with an opening. A window made of a material such as sapphire is included, with a heating element such as a conductive film disposed on the window. The camera is mounted within the receptacle and is attached to the window with an adhesive compound such as epoxy. The camera is held within the receptacle and insulated from vibration by a filler such as epoxy. An end plate holds the camera in place, and a backing plate attaches the entire assembly to the aircraft body.

The camera system of the present invention has many advantages. For example, a pilot may observe the aircraft from the cockpit, such as gear down, blown tires, hot brakes, runway/taxiway alignment, flaps, slats, flight controls, thrust reversers, and so on. In addition, passengers may observe exterior view during flight.

Other aspects, features, and advantages of the present invention will become apparent to those persons having ordinary skill in the art to which the present invention pertains from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an aircraft fitted with a surface-mounted camera of the invention;

FIG. **1a** is a fragmentary cross-sectional view of a section of an aircraft, particularly illustrating a topography thereof;

FIG. **2** is an exploded view of an aircraft-mountable camera of the invention;

FIG. **2a** is a fragmentary perspective view of a camera of the present invention, particularly illustrating a lens arrangement of the camera;

FIG. **3** is a perspective view of the camera of FIG. **2** as assembled;

FIG. **4** is a cross-sectional view of a preferred embodiment of an aircraft camera of the invention, particularly illustrating an epoxy-embedded camera within a housing;

FIG. **4a** is a schematic view of a window heater configured in accordance with the invention; and

FIG. **5** is a flowchart illustrating a method for manufacturing a camera in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings in more detail, FIG. **1** is an exemplary illustration of a camera system **10** of the present invention mounted at the tail-section of an aircraft **20**. The aircraft may be any type of solid-body aircraft, including for example a jet, propeller plane or a helicopter. Although the camera system **10** may be mounted in nearly any location along the topography of the aircraft **20**, the camera system **10** is shown mounted to a leading edge **22** of a tail section **24** of the aircraft **20**. As shown in FIG. **1a**, the surface of the tail section **24** at the leading edge **22** has a topography indicated by numeral **26**. For the purposes of this description, the camera system **10** will be described as configured to be mounted to the tail section **24**. However, those skilled in the art will appreciate that the camera system **10** may be configured to mount to other sections of the aircraft **20**, for example, a wing section **27**, a belly section **28**, or a nose section **29**.

FIG. **2** is an exemplary illustration of an exploded view of a camera system **10**, detailing the component parts. The housing **30** includes a flange portion **40** and a receptacle **50**. The housing **30** is preferably made of a strong material capable of withstanding the environmental conditions associated with aircraft flight, such as aluminum, and may be made of any material commonly used for aircraft bodies. As shown in FIG. **4**, an opening **60** is included, shown in a circular shape at the end of the receptacle **50**. Opening **60** and receptacle **50** may be any shape

that corresponds to the shape of camera **80**. A window **70** is also shown that fits within receptacle **50** and seats within the opening **60**.

As shown in FIG. **2**, window **70** may be as a circular disk and may be made of any clear material know to those skilled in the art to be capable of withstanding the temperature extremes of flight, such as sapphire. Camera **80** may be any type of camera, including a still-photography camera, video camera or any other camera known by those skilled in the art. Camera **80** has a view end **90** that houses the camera lens and an output end **100** that provides connection points for the camera control systems, power supply and other electronics. Output end **100** is shown with a plug-type connection for camera electronics, with connector **105** being shown as a corresponding plug-type connection for camera electronics. However, output end **100** may employ any type of electronic connection interface known to those skilled in the art.

An exemplary end plate **110** is shown attached to the end of the receptacle **50**, here shown attached with screws **120**. A backing plate **130** is further shown, which holds the housing **30** in place on the aircraft **20**. A heater connection for a window heater (shown in FIG. **4**) is fed into the aircraft **20** through heater connector **140**. As shown in FIG. **2a**, the camera lens **92** is recessed from the camera view end **90**, thereby defining a recess space **94** between the view end of the camera **80** and the camera lens **92**., which will be discussed in more detail below.

FIG. **3** is an exemplary perspective illustration of an assembled mounting apparatus for exemplary camera system **10**. Housing **30** is shown attached to backing plate **130**, sandwiching an aircraft skin **132** in between housing **30** and backing plate **130** and firmly attaching the entire assembly to the aircraft. Heater connector **140** is shown extending into the interior of the aircraft **20**. As can be seen, housing **30** and backing plate **130** are configured to conform in shape to the topography **26** of aircraft skin **132** to provide secure attachment and fit.

FIG. **4** shows a cross-sectional view of an exemplary housing **30**. Window **70** is shown with a heater, here depicted as a conductive film **150** disposed upon the interior surface of the window. Conductive film **150** may be comprised of any material that is both optically transparent and capable of transforming electrical energy into thermal energy. Heater wires **160** provide current to the conductive film **150**, which translates the current into heat. Solder **170** is shown connecting the heater wires **160** to the conductive film **150**. Other types of attachment may be similarly used that are known to those skilled in the art. As shown in FIG. **4a**, a heater **172** of the invention includes a control circuit **174** for providing current to the conductive film

150 through wires 160. One example of a conductive film that may be utilized is indium titanium oxide (ITO).

The camera 80 may be attached to the interior surface of the window 70 by a first portion of adhesive compound 180 such as epoxy, sandwiching the conductive film 150 between a lens 182 of the camera 80 and the window 70 of the housing 30. A second portion of adhesive compound 190, such as epoxy, may be used to loosely attach the window 70 to the interior lip 185 of the opening 60 of the receptacle 50, allowing adjustment of the camera position during assembly of the video system prior to fixing the camera firmly in place. A space 200 is defined between the camera 80 and the interior wall of the receptacle 50. This space 200 is filled with a filler 210, such as epoxy, in order to hold the camera 80 in place and insulate it from vibration. The filler 210 may be any material, know to those skilled in the art to be capable of holding the camera 80 in a fixed position.

FIG. 5 is a flowchart showing an exemplary manufacturing method for the camera mounting system. The camera heating system may be fabricated by first disposing the conductive film 150 on the window 70 (step 300) and then soldering a pair of wires 160 to the conductive film 150 (step 310). The window 70 may then be attached to the camera 80. This may be accomplished by first purging a recess space between the window 70 and the lens 182 of the camera 80, which space is indicated by numeral 312 in FIG. 4, a gaseous material such as nitrogen (step 320). The window 70 is then attached to the lens 182 an adhesive compound such as epoxy (step 330). The window/lens assembly may then be focussed by aligning the window 70 and the lens 182 to be substantially parallel with each other (step 335).

The camera 80 with the window 70 attached is then loosely attached to the interior lip 185 of the opening 60 in the receptacle 50 (step 340), and the camera 80 is then adjusted until the desired viewing position is attained (step 350). The adhesive 190 is then allowed to set in order to hold the camera 80 firmly in the receptacle 50 (step 360). The space 200 between the camera 80 and the receptacle 50 is purged with, e.g., nitrogen (step 370) and impregnated with a filler 210 such as epoxy (step 380). The end plate 110 is attached to the output end of the camera 80, and a backing plate 130 is used to attach the assembly to the aircraft (step 390). Either one or both of the plates 110 and 130 may be attached to the camera 80 while the filler 210 is setting to retain the camera in the desired alignment. When the filler 210 is set, the plates 110 and 130 may be detached to connect electronics to the camera as needed, and then reattached.

Those skilled in the art will understand that the embodiments of the present invention described above exemplify the present invention and do not limit the scope of the invention to these specifically illustrated and described embodiments. The scope of the invention is determined by the terms of the appended claims and their legal equivalents, rather than by the described examples. In addition, the exemplary embodiments provide a foundation from which numerous alternatives and modifications may be made, which alternatives and modifications are also within the scope of the present invention as defined in the appended claims.